What are Performance Measures and Performance Indicators output by the Hydrologic Models?

Hydrologic models are used to understand and simulate the potential effect water management projects may have on the natural and managed systems. The output from these models are stages (water levels) and flows (volume) for each cell in the model's grid for each time-step (daily). For each cell or group of cells within the model boundary, the stage and flow may be summed or averaged for a specified duration (daily, weekly, monthly, annually or multiple years). The stage and flow data can be displayed in the form of tables, histograms, xy line graphs, bar graphs or color-coded maps. These different types of displays are generally referred to as performance measures and indicators whether the output is from the South Florida Water Management Model (SFWMM) or the subregional groundwater (MODFLOW) models.

Performance measures are quantitative indicators of how well (or poorly) an alternative meets a specific objective. Features of good performance measures are that they are:

- Quantifiable,
- have a specific target,
- indicate when that target has been reached, or
- measure the degree of improvement toward the target when it has not been reached

Achieving hydrologic targets does not necessarily guarantee ecological restoration of natural areas nor does achieving hydrologic targets in the Lower East Coast Service Area necessarily guarantee future water supplies. It does provide the best available indication of future conditions, and this information can be used as a basis for decision making in terms of directing ecological recovery and future water allocation.

Performance Indicators, in contrast to performance measures, do not have a specific target, but are used to provide an indication of the relative behavior of alternatives. For example a stage hydrograph without specific stage targets is considered a hydrologic performance indicator.

A brief description of some of the types of performance measures and performance indicators used in the feasibility study are listed below. Performance measures are not separated from performance indicators; they are listed together. On the web page the performance measures (including indicators) will be organized geographically into those pertaining to a particular regions. Performance measures that pertain to the entire modeled domain have been placed in a regional group.

Performance Measure Sets and Model Runs

Each **RUN** is the model output for a particular base case, alternative or scenario. For example, Alternative 1, the Current 1995 Base, and the Future 2050 Base, are all runs.

A performance measure **SET** is the group of model simulation runs that are compared. For

example, a set may compare Alternative 1 with the Current 1995 Base run. Another set could compare Alternative 1, Alternative 2, the Current 1995 Base run and the Future 2050 Base run.

To view the performance measures a particular SET must be selected on the web page. The selection of a set of performance measures may be changed at any time while using the web page.

Types of Performance Measures

Different types of performance measures are displayed for each geographic region. In some cases, the type of measure is specific to that particular region while in many cases it is common to all regions. It should be noted that during the Restudy, many targets were based on the performance of the Natural System Model (NSM). The NSM simulates the pre-drainage Everglades and is used in conjunction with the SFWMM to understand how the drained system performs in comparison to simulated historical conditions. The Natural System Model (NSM) output is not comparable to output from the subregional groundwater models and will not be used in conjunction with them. Hydrologic targets will be set for the natural areas appropriate for the subregional groundwater models.

Stage hydrographs

Stage hydrographs represent the time series of a water stage at a particular location (typically, the value of a grid cell 500' x 500' for the subregional models). Stage hydrographs can be used to compare hydrograph characteristics with those of different alternatives at the specific location, providing information on how well each alternative performs with regard to the duration and severity of seasonal water level fluctuations, minimum and maximum levels, the occurrence and frequency of dry out or the duration and severity of water restrictions.

Stage duration curves

Stage duration curves provide an indication of the cumulative probability that a particular stage is exceeded or not exceeded. Stage duration curves are produced at the same locations as the stage hydrographs. From the duration curve the probability of exceeding a given stage is easily quantified for each alternative. It is useful to understand how the area performs during the high and low water extremes.

Normalized stage hydrographs and duration curves

Normalized stage hydrographs and normalized stage duration curves are used to reference stages with respect to land elevation rather than NGVD to facilitate comparison of ponding depths. This is important in comparing stages from different alternatives where land subsidence has occurred. For the subregional groundwater models, normalization facilitates understanding the ponding frequency and duration of wetland systems, while comparing ground water heads measured relative to NGVD is useful for understanding water levels near the salt-water interface or wellfields.

Hydroperiod distributions

Hydroperiod distribution maps of the model area and histograms indicate the total area inundated for 30-day inundation period classes for each of the alternatives compared. For the subregional models, a hydroperiod distribution maps for each model display the spatial distribution of the average hydroperiod for the eight-year period of record. In addition, a histogram is generated for each natural areas of interest summing the acreage in each hydroperiod class. Both the map and the histogram are divided into 30-day inundation period classes.

Groundwater Flows and Heads

To understand how water flows across large spatial areas, animations of the direction and the magnitude of volume of groundwater flows are displayed. For each model area, the change in the direction and volume of groundwater flows over time can be viewed. These changes provide a general understanding or an overview of how flows are affected.

The groundwater models segregate the aquifer into multiple layers. The top layer simulates wetlands, soil transmissivity and the top of the surficial aquifer system. Performance of groundwater heads in the top layer (layer 0 or 1 depending on the model) enables the reviewer to understand how wetlands and other natural features perform. The middle layer (layer 3 or 4 depending on the model) generally simulates the most productive area of the aquifer. Review of groundwater heads in the production zone of the Biscayne aquifer enables evaluation of groundwater withdrawals by public water suppliers.

Groundwater heads, or the elevation of the water table, as simulated by the subregional models can be displayed for large areas for either the top or middle layer. Groundwater heads are generated for each cell in the model area, then grouped together to display groundwater gradients. Changes in the gradients over time is animated for the two year increments representing wet, dry and average rainfall years and for the 8 year period of record for both the water table and the primary production zone.

To compare changes in groundwater heads between alternatives, groundwater head differences are generated for the water table (top layer of the subregional models). A cell's groundwater head at a particular date in the period of record in one alternative is compared to the groundwater head for the same location and date in another alternative. The differences for all of the cells in a model area are animated.

Indicator Regions

Performance of alternative designs will be evaluated in selected regions in natural areas. These "indicator" regions, typically represent hydrologically distinct areas of interest, and are strategically located throughout the Lower East Coast Service Area, Water Conservation Areas and Everglades National Park. Indicator regions are intended as tools to examine the hydrological behavior of small, logical subregions in the remaining Everglades. Use of indicator regions to average model output over multiple, similar cells avoids single cell comparisons and permits model output to be examined on a larger scale. Performance measures and indicators for these regions include Weekly Normalized Stage Hydrograph, Weekly Normalized Stage Duration Curve, High and Low Water Level Criteria Summary Tables, and Inundation Duration Summary Table.

Water Budget

The water budget performance measures present graphically the volume of water that comes into (positive) or leaves (negative) each particular area on average annually. Each term of the water budget is shown for each alternative. Water budget terms include rainfall, evapotranspiration, groundwater flows, structure flows, water supply withdrawals, and changes in storage. A residual term is also shown to verify conservation of mass and accounting. These will be applied to drainage basins in the subregional groundwater models.

Groundwater Flow: Seepage and Transects

Groundwater flows are integral to several performance measures and indicators. Groundwater flows across a transect are summed for a specific duration (usually monthly or annually). Transects are usually located near a water management feature, structure, levee or canal, to understand how the magnitude and timing of groundwater flows are affected. To measure groundwater flow from the Water Conservation Areas and Everglades National Park to the Lower East Coast Service Areas transects are located along the protective levees. To measure seepage from WPA components, transects surround the external levee of the above ground reservoirs.

Water Supply Restrictions

There are several performance measures that characterize the severity and duration of water supply cutbacks imposed on legal water users when regional or local storage is diminished during droughts. Water supplies are reduced (cutback) due to low groundwater stages in selected "trigger" cells in the Lower East Coast, low surface water stages in Lake Okeechobee or continuation of the restriction through the end of the dry season. Maps show the location of low ground water levels, bar charts display the average annual volume cutback by use type as well as the annual volume of cutbacks by the cause, and stage hydrographs are produced for the trigger cells in the Lower East Coast Service Area.

Water Preserve Area Components

Monthly Summary Report for Water Preserve Area Components: Monthly summary reports for the WPA components, for example the Hillsboro Impoundment, provide information useful to understand how the component operates in the subregional groundwater models. Types of information included are effective recharge, evapotranspiration, seepage, inflows, discharges, and water quality parameters.

Stage Profiles: To assess potential changes in maximum and minimum stages within a WPA component or in the surrounding area, stage profiles are utilized. Stage profiles rely on transects that generally extend from the Everglades through WPA components and into urban areas, wellfields or wetlands east of the protective levee. The maximum, minimum and average stage for the period of record is recorded for each cell composing the transect. The land elevation is also included to provide a spatial reference point. The end result is not a time-series, but a representation of the extreme and average conditions at selected locations.